LONG DURATION BALLOON
OPTIONS FOR INCORPORATION OF
NASA TDRSS HIGH GAIN ANTENNA (HGA)
AND SUPPORTING SUBSYSTEMS

23 AUGUST 2001

Summary

The NASA Balloon TDRSS High Gain Antenna (HGA) subsystem may be offered to MIDEX science users as one of the following options:

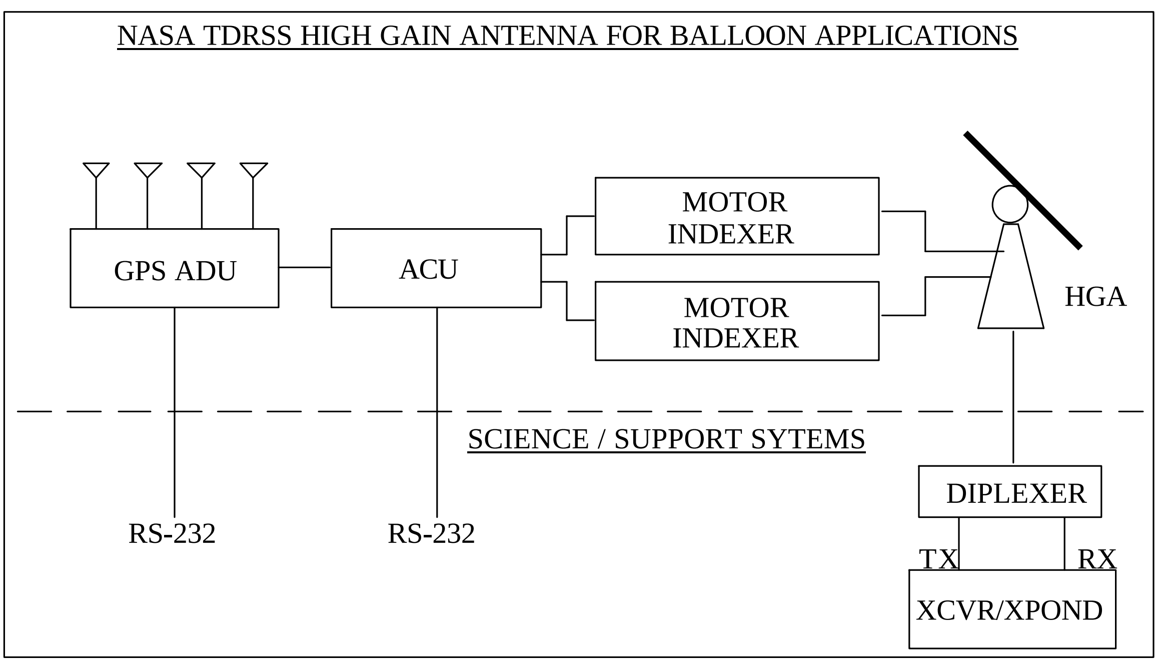
Option #1: Science users may procure the HGA system to incorporate into their own telemetry systems that they provide.

Option #2: Science users may incorporate the HGA as part of the LDB SIP to achieve higher "return" telemetry rates than those discussed in the original document "Middle-Class Explorer Library Long Duration Balloon Opportunities."

With Option #1, the science user assumes a greater level of systems engineering and systems support responsibility. With Option #2, the NASA Balloon Program Office will offer all the systems engineering and operational support required for the HGA.

HGA Configuration (Option #1)

The following drawing shows the configuration of subsystems provided under Option #1 as shown for those items above the dashed line.



The HGA has demonstrated, in flight, the capability of supporting up to 150 kbps return telemetry at less than 10^{-6} bit error rates for MA combined mode (same data over both I&Q channels.) Costs for Option #1 are as follows per current FY'01 pricing (add appropriate inflation increases concurrent with anticipated year of purchase):

Parts and Labor: $65K

The above cost does not include any spares, warranties, or support after delivery. It only includes the subsystems illustrated above the dashed line in the preceding configuration drawing. Documentation is also included.

As an option, additional support may be arranged for users requesting training, integration and test support, or field support at a cost of $4K/week exclusive of travel and per diem costs. Add travel and per diem costs for two people, as appropriate for your particular requirements, when electing the option for any of this support.

With the above configuration, the HGA will auto point to the appropriate TDRSS satellite. Additional control flexibility and in-flight configuration changes can be exercised by interfacing the GPS ADU and ACU to the science computer. Details of these controls would be described in the HGA User's Manual, which is not available for release at this time. Plan one year for delivery ARO. Obligation of funds would be required prior to beginning fabrication.

HGA Configuration (Option #2)

Users may elect to integrate the TDRSS HGA into the LDB SIP. At this time, integration with the LDB SIP has not been accomplished as the HGA was developed under the NASA ULDB development project. With Option #2, the NASA Balloon Program will take care of all HGA integration and support issues. Science users will realize the same data rate capabilities, as under Option #1, but the science interface will be through the SIP "science data and command interface." The SIP would include the TDRSS Transponder (or Transceiver), diplexer, control of the GPS ADU and ACU. Integration and testing of the HGA on the science gondola will be supported by the NSBF with Option #2. Costs for Option #2 are as follows per current FY'01 pricing (add appropriate inflation increases concurrent with anticipated year of purchase):

Parts and Labor: $271K

No options for additional labor are required as the above cost includes all integration and support, spares, and field support. The above cost also includes onboard storage by the SIP of science data, at the rates supported by the HGA. Obligation of funds would be required prior to beginning start of fabrication and integration with the LDB SIP. Plan one year for lead time prior to payload integration.

.

HGA QUESTIONS AND ANSWERS

Following are questions and answers that provide further detail about the HGA. Users should keep in mind that the development of the HGA and flight verification of its performance is very recent. This addendum is for the purpose of allowing users to consider future capabilities and therefore, it may not be as comprehensive as everyone would like. This information is provided with the intent of providing proposers sufficient information as to adequately incorporate this option as part of their initial proposal efforts. A Users Manual is not currently available; therefore, the following questions and answers are provided to assist with making a more informed decision about use of the HGA

Q - If this system were made available to experimenters, would it be supplied as a complete NASA-WFF supported system, where the experimenter only needs to mount it and connect science-interfacing cables to it?

Answer: The NASA Balloon TDRSS HGA (High Gain Antenna) system is comprised of the HGA antenna, 2ea. motor indexers, attitude control unit (ACU), attitude determination GPS (GPS ADU), quad GPS antennas and boom, and associated cabling. All but the attitude determination GPS is built by NASA. The attitude determination GPS is an off-the-shelf Ashtech model ADU2. The NASA TDRSS HGA system is designed to operate only with the Ashtech ADU2. For users who provide their own TDRSS transponder/transceiver, NASA would provide the system as depicted in the preceding drawing for those subsystems shown above the dashed line. As supplied, the system would include flight-qualified components that have undergone functional testing and environmental testing. Also included will be documentation and interconnecting cables for the GPS Antennas-GPS ADU-ACU-INDEXERS-HGA. The user will provide (Option #1) RS-232 cables, diplexer, transponder or transceiver, and TDRSS RF coax. In addition to a mechanical and electrical ICD, documentation will include environmental characteristics as well as installation, checkout, and operation procedures.

For users who opt to have the HGA integrated as part of the LDB SIP (Support Instrument Package) as Option #2, NASA will take care of all HGA interfacing, testing, and operation. In this case, the science user only has to connect with the SIP data and command interface.

Q - Is there sufficient link margin for successful 100kbps science downlink for either a Fairbanks or McMurdo LDB flight? Will this system give approximately the same coverage as lower rate TDRSS system that you have flown on LDB polar flights?

Answer: As of this writing, the HGA has not demonstrated 100 kbps data rates for either the Fairbanks or the McMurdo, Antarctica latitudes. It has been flown on one test flight launched from Fort Sumner, New Mexico during which it operated flawlessly for 24+ hours at 50 kbps in the MA mode. During this same test flight, the HGA operated flawlessly at 150 kbps MA mode during two each, ten minute long events, using a flight configured bit error rate test generator. During the 150 kbps BER tests, errors were less than 10^{-6}. Calculated link margins for McMurdo latitudes (~78° South) show that greater than 90 kbps data rates can be expected with the HGA. However, these calculations have historically proven to be over conservative and 100 kbps are believed to be achievable with the HGA using a properly configured transponder/transceiver, diplexer, and cabling operated in the combined mode (same data on both the I & Q channels).

Q - Does the system check that downlinked data is successfully received on the ground?

Answer: Users must incorporate their own error checking within their data. The TDRSS Network and the OCC (Operations Control Center) at NSBF can verify reception of the RF signal, but not the integrity of data.

Q - How will the system manage data flow during downlink outages? Please note that we are planning to have our experiment record science data on disk at all times in addition to the downlink.

Answer: If the science users provide their own telemetry systems, then they are responsible for providing their own onboard telemetry backup data storage and retrieval subsystems. If the LDB SIP is utilized for return science data, the SIP incorporates data archiving that can be played back, during flight, to recover any data losses due to telemetry outages. The TDRSS Network provides 24 hour running backup of all return telemetry received at the ground station in order to mitigate risks of loss due to ground network outages or interruptions.

Q - Right now we are considering the new system as a separate piece of hardware for science downlink only, with a SIP for all other command and telemetry. Is this approach consistent with LDB requirements, or would the LDB flight support system use some of its capability as well?

Answer: This approach is allowed. The SIP will be flown with its own TDRSS configuration and will not utilize any of the science user provided telemetry subsystems. Users must keep in mind that additional cost for TDRSS support services must be accounted for under this configuration. Also, under this configuration, the science user must account for TDRSS network scheduling, data access, and ground support as this requires additional resources not accounted for by the NASA Balloon Program Office.

Q - We will need to get the DGPS attitude, position, time, and status data for the experiment systems. Can this be made available to us on-board on a real-time basis? Can you tell us what the accuracy of the GPS time tag is?

Answer: As shown in the HGA configuration drawing, a RS-232 interface is provided to the science user by which GPS ADU housekeeping status may be accessed. If using the HGA as incorporated with the LDB SIP, this same data may be accessed via requests sent to the SIP flight computer. The GPS time tag is the time of the GPS position fix and is usually accurate to within a second. However, this is not a GPS time code generator and users requiring high timing accuracy should consider use of a separate on board time code. Additional specifications for the Ashtech ADU2 can be found on the company web site.

Q - We would like to verify that the moving components of the antenna system do not interfere with our servo systems. Can you describe the motions, masses, etc. for us so that we can make this determination? Does the system continuously move, or does it seldom move? Can movements be programmed for times that would not interfere with science observations?

Answer: The HGA is an azimuth over elevation 2-axis pointing TDRSS antenna. It has the following specifications. Axis #1 is 12 inches from the base with a moving mass of 10.523 lbs (4.773 Kg) and moves at a rate of 1.5 degrees per second. Axis #2 is 14.5 inches from the base with a moving mass of 3.289 lbs (1.492 Kg) and moves at a rate of 3.0 degrees per second. Movements in both axis incorporate a controlled slewing that slows the rates as the unit approaches point. The unit continuously moves to keep the antenna pointed at the satellite. It should be kept in mind that this constant movement consists primarily of small correction adjustments. At the risk of losing adequate link margin for higher data rates, the HGA can be commanded off so that it does not affect other pointing systems.

Q - What is the unobstructed field of view required by the antenna?

Answer: The HGA antenna is an 18 X 18 inch flat planar array. Half power points are nine degrees off-normal measured along each edge. Normal mounting configurations would include placing the HGA on the top side and outboard on a boom away from the main gondola structure. Experience has shown negligible effect when looking through 5/8 inch steel suspension cable at a distance of six feet.

Q - From previous discussions and perusal of your web site, we believe that the pointed antenna system consists of the following:

- **TDRSS Pointed antenna and dome**
- **TDRSS Transponder**
- **TDRSS Transponder Interface**
- **Differential GPS receiver and antenna system**
- **All required software and related equipment**
- **Required GSE**
- **Selected spare parts**
- **Technical, integration, and flight support**

Is this correct?

Answer: Until now, the TDRSS HGA system has not been offered to anyone outside of the ULDB development project. Any information found on any other web site or other documentation describing the NASA ULDB TDRSS HGA system should not be construed as what would be offered to the MIDEX science user. The elements that comprise the TDRSS HGA are as previously described. Beyond making available the TDRSS HGA, the balloon program is not offering to provide transponders or transceivers, transponder interface, GSE, technical support, flight support, or spare parts for any user who elects to integrate the HGA to their own telemetry support systems versus using the LDB SIP. The TDRSS HGA carries no warranties, implied or otherwise. It would be delivered to the user as being flight qualified. For science users planning to use the TDRSS HGA in support of their own telemetry systems, it is the user's responsibility to insure that proper handling and mounting, system integrations, thermal control, and operation of the system is consistent within parameters of the unit. Science users wishing to incorporate the TDRSS HGA into the LDB SIP will be fully supported for the entire TM system, to include necessary spares, integration, operation, etc.

Q - Is the power for the system provided by NASA-WFF and accounted for in the support system power budget? If not, we will need to know what the power requirements are.

Answer: Science users are responsible for providing power for all subsystems exclusive of those integrated with, and part of, the LDB SIP, Universal Terminate Package, and NASA provided balloon rotator. Therefore, if a science user is integrating the TDRSS HGA with his or her own telemetry subsystems and science flight computer (exclusive of the LDB SIP), then the science user is responsible for providing power to the TDRSS HGA. Including the ACU and motor indexers, the HGA requires:

Power while moving:	5vdc @ 2.45W
	28vdc @ 10.64W
Quiescent:	5vdc @ 2.45W
	28vdc @ 6.5W

Power requirements for the Ashtech GPS ADU can be found on their web site and will vary in accordance with how the science user intends to operate. In addition, depending upon the gondola configuration and trajectory, heaters will likely be required for the motors and HGA encoders.

Q - What are the electrical interface requirements for the system?(Interface functions and types of interface…serial, parallel, etc.).

Answer: As the configuration illustration above shows, there is a RS-232 interface for both the GPS ADU and the ACU. There are numerous parameters and control commands that can be sent to the GPS ADU and these can be found on the Ashtech web site. The ACU provides status information and capability of commanding the TDRSS HGA in various modes. The TDRSS HGA documentation will be provided and will define all these functions. In addition, there are power connectors and the RF interface to the antenna.

Q - What are the mechanical interface requirements? Is a drawing available?

Answer: The GPS, ACU, indexers and antenna are discreet components that can be bolted onto the gondola structure. AutoCAD files will be made available for those requesting more detailed information.

Q - What is the mass of each of the antenna system flight components?

Answer: Mass of the major elements shown above are:

GPS ADU:	5.5 lbs (2.5Kg)
GPS Antennas & Quad Boom:	8.5 lbs (3.9Kg)
ACU:	1.0 lbs (0.5Kg)
Motor Indexers:	0.5 lbs (0.23Kg) Each
HGA:	18.9 lbs (8.6Kg)
Cabling:	2.0 lbs (0.9Kg) Est.

Q - How does NASA-WFF deal with the downlink services (SOMO, etc.)?

Answer: The balloon program handles all scheduling, payment, etc. related to SOMO/CSOC services for LDB SIP support. NSBF takes care of scheduling TDRSS events for LDB SIP support.

Science users planning to provide their own TDRSS telemetry subsystems (integrated systems which are not part of the LDB SIP) must account for making arrangements for network scheduling, service support costs, and ground station interfacing.

Q - What will be the costs for this system that must be borne by the experimenter in the MIDEX proposal, and what will be the phasing of the costs? Can a schedule for flight in the spring of 2006 be supported?

Answer: See above Option #1 and Option #2.

Q - What is the azimuth accuracy of the ULDB DGPS system? Is it affected by latitude, GPS satellite position, or other factors?

Answer: Assuming that the question is with regard to the azimuth pointing accuracy of the TDRSS HGA, the overall pointing accuracy is better than 1 degree. If the question is really about the attitude determination accuracy of the GPS ADU unit itself, then users may find that information on the Ashtech web site. The predominant factor affecting accuracy is the spacing of the four GPS antennas. The further the separation of the GPS antennas, the greater the accuracy. The TDRSS HGA utilizes GPS antennas mounted one meter apart.

Q – Since it is recommended that the MIDEX user plan to fund the construction of a new SIP tailored to his requirements, can a single SIP design support both Fairbanks and McMurdo LDB flights? If so, what would be its properties and cost?

Answer: A single SIP can support both Fairbanks and McMurdo. However, the two configurations as defined in the MIDEX “Long Duration Balloon Opportunities” document would remain unchanged. Antarctica would require TDRSS/HF and Fairbanks would require TDRSS/INMARSAT. To achieve this, an INMARSAT and HF communications system could be swapped out for each other depending upon the launch location. There would be no difference in the other "properties" to achieve this capability. The SIP configuration for both INMARSAT and HF are identical. Swapping out the INMARSAT and HF transceivers along with a few cables is all that is involved with configuring for either of these two launch sites. The INMARSAT and HF communications systems costs are about the same. If the science user wishes to procure a single SIP, an additional $10K will support the option of flying the same SIP from either Fairbanks or McMurdo.